Solarsystems

Solar System and Hot Water Brief Report

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SOLAR DECATHLON EUROPE 2010

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At the beginning of the project, various approaches for identifying the best solar system were considered. After evaluating our research and calculation results, we decided – especially with view to the competition situation - to use a combination of photovoltaics and heat pump, because it turned out that the waste heat generated during refrigeration is sufficient for water heating. In this way the waste heat of the compression refrigeration system, which is generally considered to be a mere „by-product“, is effectively used.

1. Solar thermics

A more detailed analysis of the climate dates for the location Madrid showed that the number of sunshine hours, and accordingly also the necessary cooling energy, in the summer months is very high.

Obviously, the highest cooling requirement occurs during maximal solar radiation. Thus the approach of generating the necessary cooling energy by making use of the principle of solar cooling suggested itself.

Description	Number of pieces	Per unit	all units
Solar collector	25 m²		
Storage 2 m²	2		
Drink water storage	1		
Absorption refrigeration	1	20W	20W
Heat Pump	1	1500W	1500W
Heat exchanger	1	500W	500W
pumps	8	40W	320W
total			2340W

Solar cooling – key data

2. System design

A clear advantage of solar cooling is the high efficiency factor of the solar thermics collectors and the possibility to generate cold directly from solar radiation. The high temperature level of the waste heat (30 – 35 °C) could principally also be used for other processes, such as e.g. floor heating.

However, in the case of a single-family home the disadvantages outweigh the advantages, as big collector surfaces are necessary to reach the required temperature level. In our case this would have been approximately 40 % of the entire energy generation surface (roof surface). When comparing the gain from the same surface when used for photovoltaics (approximately 6400 kWh/a) and solar cooling (approximately 850 kWh/a, thermally), it becomes very clear that the option of using the heat pump is clearly superior with respect to the energy balance.

Another problem when using solar cooling is the maximal cooling requirement (which in our case lies at 3 kW), as according to the manufacturer only from 10 kW upwards a technically flawless operation can be guaranteed.

This would inevitably lead to a system, that is three times bigger than appropriate for our concept. The waste heat generated in a temperature range of 30° - 35°C would not be usable in the competition situation. Raising the temperature to 43°C (hot water) by electrical means would be necessary in order to be able to use the system in a sensible way. The dimensions and complexity of the systems engineering system, too, suggest that this concept must be dismissed.

The second approach, which took into account the annual requirement, comprised a combination of photovoltaics and solar thermics. According to simulations, the surface requirement of approximately 6 m² for solar thermics would be sufficient (and thus would

be reduced to a minimum) to cover the warm drinking water requirements for a two person home and the heating requirement for this optimized house in winter.
In the location Madrid heating loads can be considerably reduced because of the optimized heating envelope and through the solar gains of the big window surfaces of the southern façade.

A regulation of the room temperature can also be reached in winter through flexibly controlled shading.

Generally, the building services concept is designed so that in the case of normal use the systems radiation cooling and PCM channel can cover heating and cooling loads in combination with the building performance. The peak loads during the competition (public tour, visitors) and their compensation within an hour make it necessary for us to integrate a heat pump into the system so as to provide the cooling requirement under competition conditions.
So the waste heat of the compression engine would have to be recooled at the high outdoor temperatures with much energy and technical effort. Considering this, we have decided against the installation of solar thermics and for the use of the waste heat generated by the heat pump to domestic hot water.
This can be realized very easily through buffering the waste heat in a 300 liter storage in combination with a heat exchangers.

Simulations show, that during the competition approximately 30 kWh in thermic energy can be generated for hot water preparation. An efficiency factor (COP) of approximately 3 for the heat pump corresponds to a power consumption of 10 kWh for water heating. More detailed analyses even showed, that through solar thermics collectors with a surface of 6 m2 60 kWh less power is generated during the competition period . Here it becomes very clear, that the combination of photovoltaics and heat pump we have decided for works much more efficiently under competition conditions . The „waste heat“ is effectively used, while the power input is raised by 50 kWh.

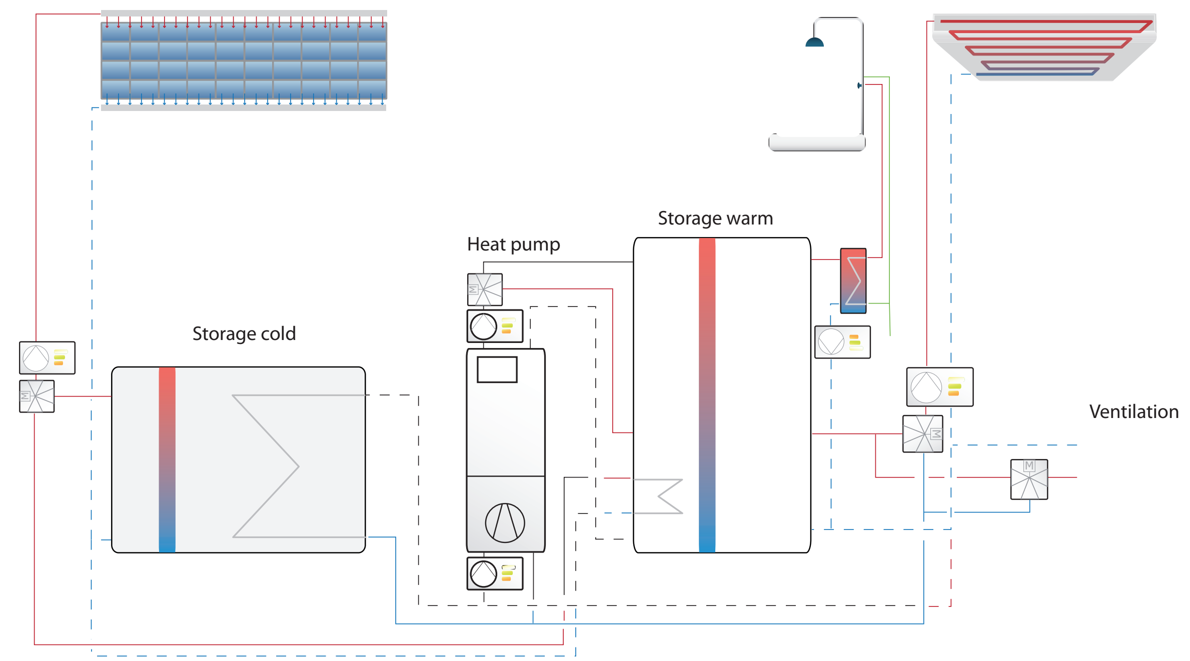


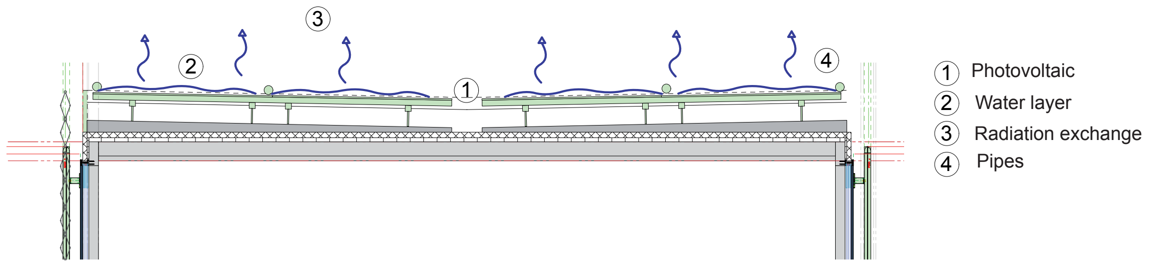
Diagram building services

3. Photovoltaics

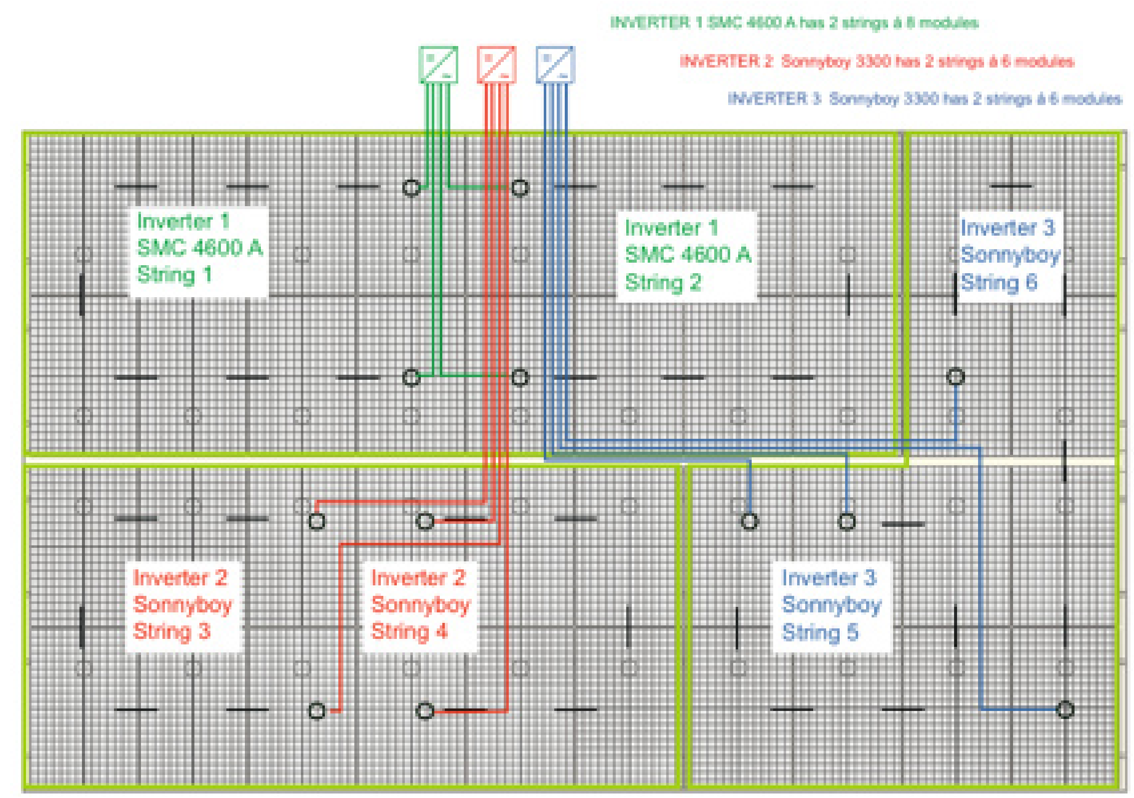
As the energy use surface is limited in the competition, we are facing the challenge of using it as efficiently as possible. We have chosen the mono-crystalline photovoltaics module 315 WTH by Sun Power Company. The module comprises 96 mono-crystalline cells, through which the maximal value of 193 wattpeak/m2 can be achieved. Through the optimal size of the module, we could accomodate 40 pieces and thus cover 69m2 of the 72m2 roof surface with photovoltaics.

The 3° degree tilt of the photovoltaics system to the center of the roof has been chosen with view to the framework conditions for radiation cooling (for details, please see engineering & construction). This arrangement facilitates an optimal wetting of the surface for radiation exchange.

The used inverter bz SMA are among the most efficient and are characterized by the highest efficiency factors on the market.



Position photovoltaics



PV wiring

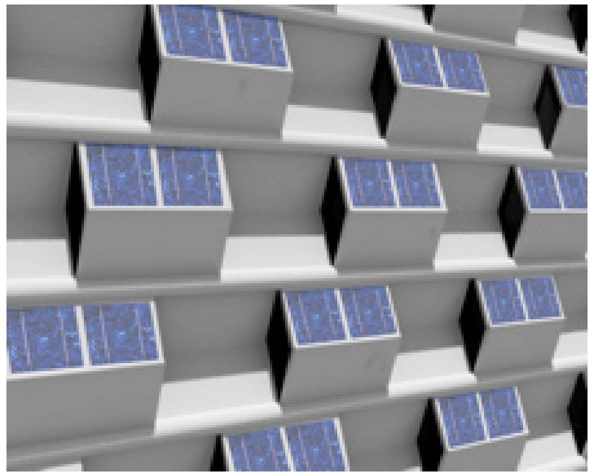
The following appliances were used:
- Sunny Mini Control, 4600 A, 2 strings a 8 modules
- Sunny Boy, 3300 A, 2 strings a 6 modules
- Sunny Boy, 3300 A, 2 strings a 6 modules

Location	Madrid
Climate data	Meteonorm (1995 – 2006)
Photovoltaic – Power	12,6 kwp
Photovoltaic area	69,00 m^2
Radiation on the System	109.085 kWh
Generation on the AC side	16.180 kWh
Generation to the Grid	16.180 kWh
Systems efficiency	14,8 %
Annual effective yield	1282 kWh/kWp
CO^2 reduction	14.311 kg/a

Table: Characteristic values PV

4. Facade

The idea of developing the facade as an energy source arose during the design process. Here, thin film cells are installed on the facade surface in such a way that they do not cast shadows on each other. This is how the unusual shape of the „zigzag" shading was created. The surfaces of the individual jags have a size of 14 x 28 cm, so that two wavers of respectively 12,5 cm x 12,5 cm can be arranged on them. This inspired the structure as illustrated in the image below.



Zigzag shape of photovoltaics

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